



# **Integrating EEG and MEG information to enhance motor-imagery classification in brain-computer interface**

Marie-Constance Corsi, Mario Chavez, Denis Schwartz, Laurent Hugueville,  
Ankit Khambhati, Danielle S. Bassett, Fabrizio de Vico Fallani

## **► To cite this version:**

Marie-Constance Corsi, Mario Chavez, Denis Schwartz, Laurent Hugueville, Ankit Khambhati, et al.. Integrating EEG and MEG information to enhance motor-imagery classification in brain-computer interface. BIOMAG 2018 - 21st International Conference on Biomagnetism, Aug 2018, Philadelphia, United States. hal-01966311

**HAL Id: hal-01966311**

**<https://hal.science/hal-01966311>**

Submitted on 28 Dec 2018

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



# Integrating EEG and MEG information to enhance motor-imagery classification in brain-computer interface

M.-C. Corsi<sup>1,2</sup>, M. Chavez<sup>2</sup>, D. Schwartz<sup>3</sup>, L. Hugueville<sup>3</sup>, A.N. Khambhati<sup>4</sup>, D. S. Bassett<sup>5</sup>, F. De Vico Fallani<sup>1,2</sup>

<sup>1</sup>INRIA, Aramis project-team, Institut du Cerveau et de la Moelle Epinière, ICM, Inserm U 1127, Sorbonne Université, F-75013, Paris, France

<sup>2</sup>CNRS UMR7225, Hôpital de la Pitié Salpêtrière, Paris, France

<sup>3</sup>Centre Neuroimagerie de Recherche - CENIR, Centre de Recherche de l'Institut du Cerveau et de la Moelle Epinière, Université Pierre et Marie Curie-Paris 6 UMR-S975, Inserm U975, CNRS UMR7225, Groupe Hospitalier Pitié-Salpêtrière, Paris, France

<sup>4</sup>Department of Bioengineering, University of Pennsylvania, Philadelphia, PA, 19104

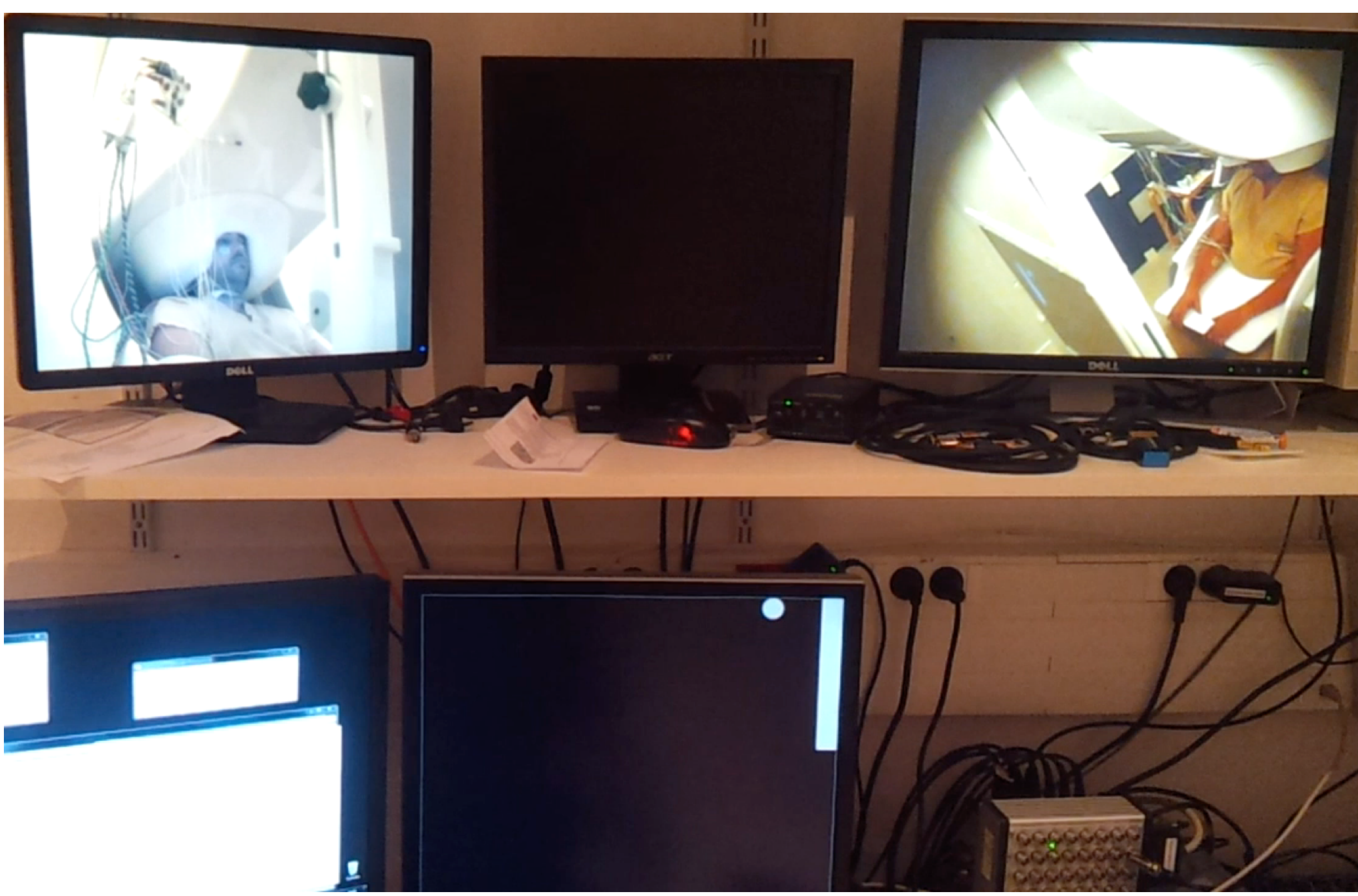
<sup>5</sup>Departments of Bioengineering, Electrical and Systems Engineering, Physics, and Neurology, University of Pennsylvania, Philadelphia, PA, 19104

Brain-computer interface (BCI) is a potential tool for rehabilitation and communication that mainly relies on the electroencephalography (EEG). Despite its clinical applications, BCI faces to both engineering and user-oriented challenges to improve its spreading. In this work, we assess the possibility of integrating electroencephalographic (EEG) and magnetoencephalographic (MEG) signals to enhance the classification performance in motor imagery-based BCI. By adopting a matching-score fusion approach (in an offline fashion) that optimizes the choice of the features in each individual, we reached an average classification improvement of 12.8 % as compared to separate EEG and MEG classifiers. These results could promote multimodal BCIs development.

## Methods

### BCI protocol

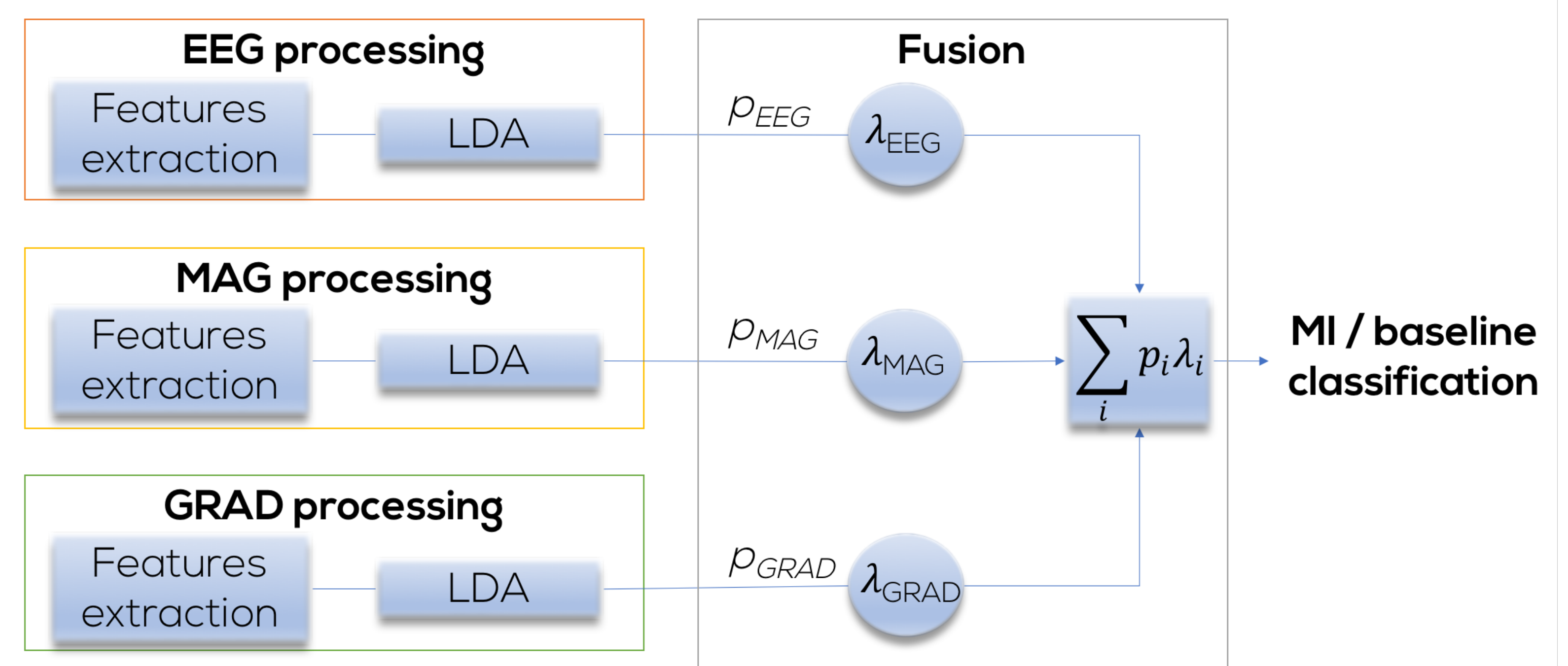
Fifteen healthy subjects (aged  $28.13 \pm 4.10$  years, seven women) participated to the protocol



**Fig. 1:** BCI experiments performed at the CENIR. MEG and EEG are simultaneously recorded with, respectively: an Eleka Neuromag TRIUX machine® (204 planar gradiometers and 102 magnetometers) and a 74 EEG-channel system. The task consists in a 1D, 2-target, right-justified box task where the subject performs a sustained MI (grasping) of the right hand to hit up-targets, while remaining at rest to hit down-targets.

### Fusion approach

No artifact removal method applied here to simulate online scenarios.



**Fig. 2:** Classifier fusion approach for a given frequency bin. The variables  $p_i$  and  $\lambda_i$  stand for the posterior probability and the weight parameter associated with the modality  $i$ .

Semi-automatic procedure to extract features:

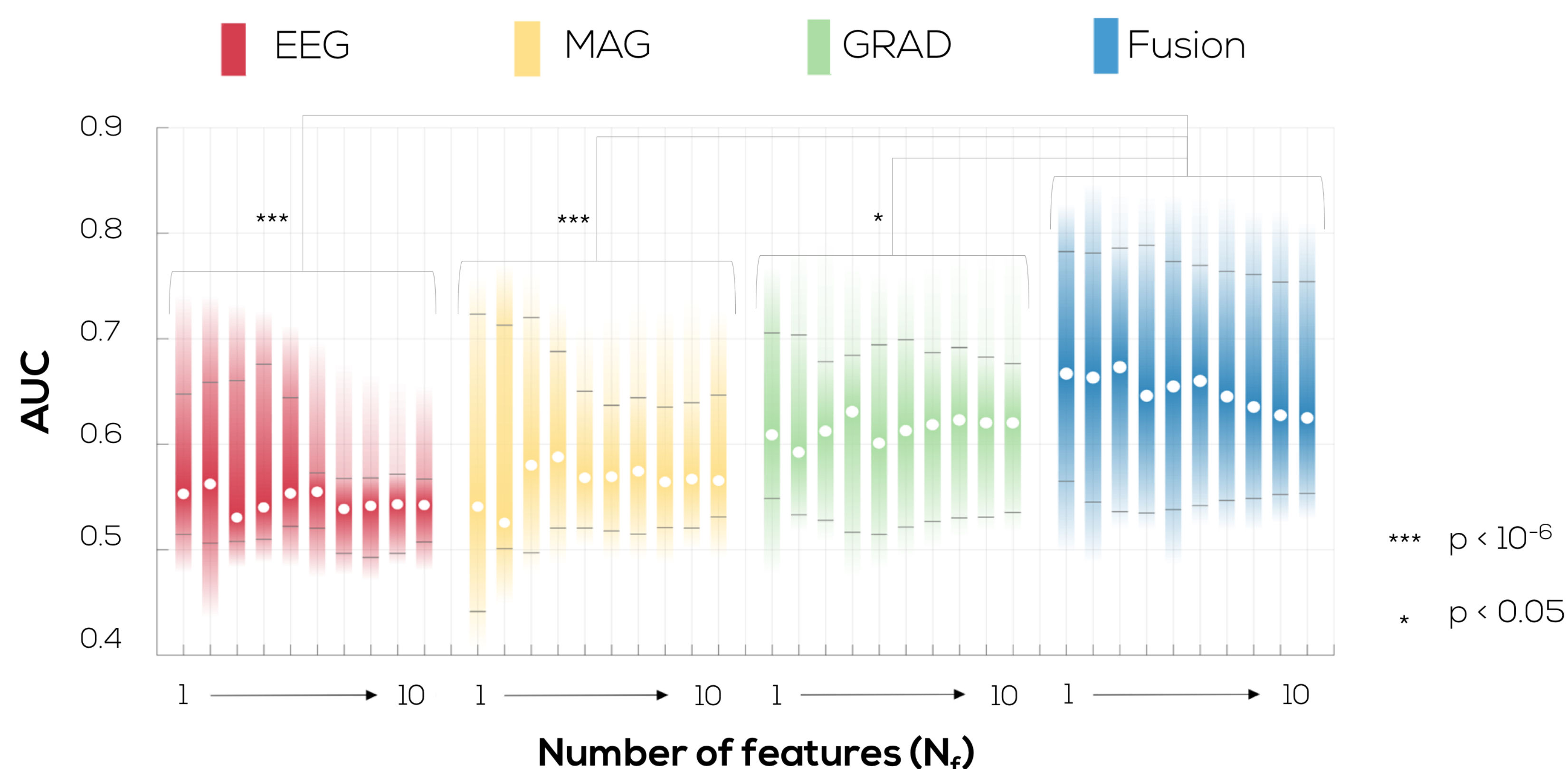
Focus on motor area contralateral to the imagined movement

Nonparametric cluster-based permutation t-test between power spectra of MI and rest epochs

Extraction of the  $N_f$  most discriminant features within the standard frequency bands

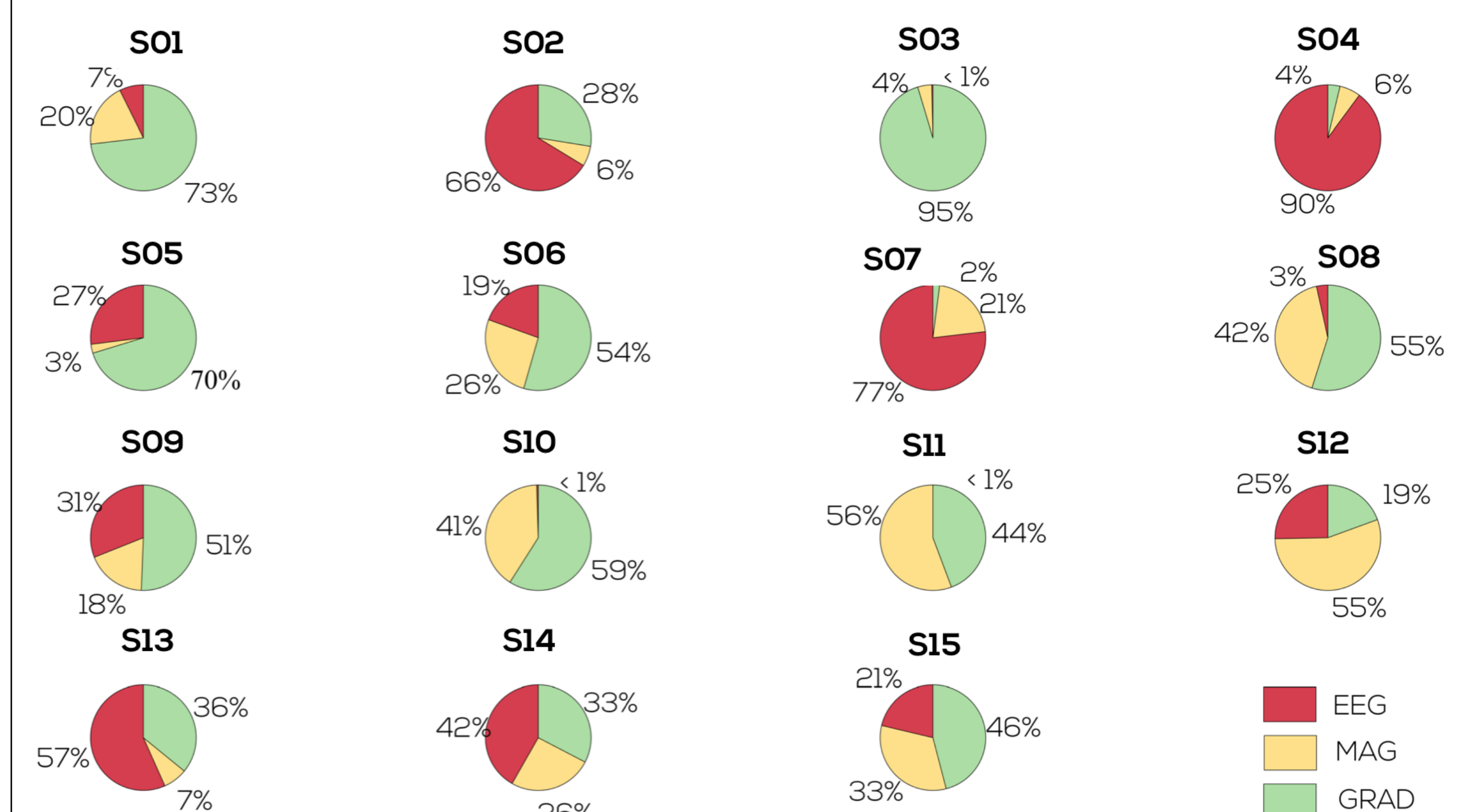
## Results

### Classification fusion enables a significant performance improvement



**Fig. 3:** AUC distributions across the 15 subjects, for all the modalities, and for different numbers of features within the alpha-band. White circles correspond to the median values. In all frequency bands, the type of modality significantly affected the AUC values (ANOVA,  $p < 10^{-3}$ ), whereas the number of features did not have a significant impact ( $p > 0.05$ ).

### Inter-subject variability: attributed weights



**Fig. 4:** Contribution of different modalities to the individual performance. Pie-diagrams show the  $\lambda_i$  values (in percentage) obtained for each modality via the fusion approach.

## Acknowledgments

This work was partially supported by French program "Investissements d'avenir" ANR-10-IAIHU-06; "ANRNIH CRCNS" ANR-15-NEUC-0006-02 and by Army Research Office (W911NF-14-1-0679).

marie.constance.corsi@gmail.com